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Striking a Balance Between Innovation and Standards: A Study of Teachers Implementing Project-Based Approaches to Teaching Science

Regina E. Toolin¹

This research reports on the efforts of six middle school and high school science teachers in a public school district in New York City to balance innovative teaching methods and strategies with the New York State Learning Standards and Regents requirements. More specifically, this research examines the factors that influenced the implementation of project-based approaches to teaching and learning science. Observations of meetings and classrooms, and collection of artifacts such as curricula, project planners, demographic profiles, student work, and test results served as the primary data sources that were triangulated and related to current theory on project-based learning in science. Four teachers embraced aspects of project-based learning in science and two rejected most aspects of teaching project-based learning in science. Implications for science professional development are discussed.

KEY WORDS: project-based learning; secondary science teachers; science professional development.

INTRODUCTION

In today's standards-based schools, teachers are faced with the constant pressure to balance innovative and meaningful curriculum and teaching with the demands of state-mandated curriculum and assessments. In New York State, many middle school and high school science teachers are caught in a juggling act as they simultaneously try to meet the rigorous demands of the New York State Learning Standards for math, science, and technology (MST), to prepare their students for either the intermediate level science test or the high school Regents science examinations and to contextualize their curriculum and teaching so that students are engaged in relevant, meaningful, and inquiry-based science learning. Depending on their background and experience, some teachers forfeit innovation and creativity by adhering primarily to the New York State Curriculum Guidelines and test preparation guidelines. Others pay little regard to the

State requirements and focus on topics and projects that are of interest and relevance to them and their students. Still others attempt to strike a balance between innovation and the State requirements by incorporating, for example, project-based approaches into their science curriculum and teaching.

This research reports on the efforts of six middle school and high school science teachers in a public school district in New York City to balance innovative teaching methods and strategies with the New York State Learning Standards and Regents requirements. More specifically, this research examines the factors that influence the implementation of project-based approaches to teaching and learning science.

LITERATURE REVIEW

The history of doing "projects" can be traced to Dewey and other progressive educators and more recently to research done by Polman (2000) and Krajcik *et al.* (1999). The goal of project-based learning is to investigate real-world, standards-based problems that are of interest, relevance, value, and worth to

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students and teachers over a sustained period of time. “Projects” are defined by questions or problems that are collaboratively investigated by students and teachers utilizing technology and resulting in a series of artifacts or products that address the question or problem over time (Krajcik *et al.*, 1999).

Project-Based Teaching

Researchers have found that teachers are generally enthusiastic, motivated, and successful in their quest to implement project-based learning in their science classrooms (Boss, 2002; Rosenfield and Ben-Hur, 2001). D’Amico (1999) reported on the challenges that teachers faced as they designed assessments, created new courses, or revised existing ones in support of project-based science. Other studies (Blumfield, 1994) reported on the positive change in teachers’ understanding and practice of science and science teaching as they collaborated to develop a project-based science curriculum.

Project-Based Learning

Researchers have found that student motivation and learning increased in the project-based science classroom. Marx (1994) found that student collaboration and the use of technology increased as teachers enacted several aspects of project-based science in their teaching practice. Stratford and Finkel (1996) reported that project-based science promoted positive change in students’ ideas about science classes, attitudes about science, and motivation for studying science. Yarnall and Kafai (1996) reported that project-based teaching heightened student motivation and commitment to learning while developing ocean software design projects.

DISTRICT, SCHOOL, AND STUDENT DEMOGRAPHICS

The Professional Development District

The NYC public school district is known locally and nationally for its educational innovation and reform programs, particularly in literacy and mathematics. In the past 8 years, seven new middle schools and high schools have been established on the basis of the philosophies of teaching and learning espoused by New Visions, New Standards, Principles of Learn-

ing, Outward Bound Expeditionary Learning, and the Coalition for Essential Schools. The mission of this district is quite clear and can be summarized by three distinct questions articulated by district administrators as they “walk through” and evaluate schools and echoed by principals as they support district initiatives and evaluate their teachers: What is important for students to know and do? What resources need to be in place in order for students to learn in relevant and meaningful ways? What is the evidence that students are actually learning?

Until recent citywide budget cutbacks, every teacher in the district had access to a professional developer on a weekly and sometimes more frequent basis. Literacy and math professional development programs were firmly established in the district and were often supported by either private or government grants. What is relatively new is a systemic initiative to reform science education at the middle and high school levels.

Over the past 4 years support for science education has come in the form of a variety of professional development opportunities including the hiring of science professional developers; four quarterly workshops focused on project-based curriculum development; a weeklong summer science curriculum workshop; and support for teachers to attend NYU’s Urban Science Education Conference and other research-based programs at Columbia and Rockefeller Universities. In addition, state-of-the-art science labs were completed in the fall 1999 supported financially by the NYC Department of Education (formerly called the Board of Education) and private funders.

Community of Science Educators (COSE)

In order to bring together teachers and staff developers who would otherwise be isolated from other science colleagues around the district, a cohort of district science staff developers and science teachers collaborated to form “COSE” or the Community of Science Educators. In addition to a COSE list-serve that allowed teachers and staff developers to communicate ideas, curriculum, and workshop dates; one of the primary initiatives of COSE was to provide staff development that emphasized a project-based approach to science teaching. These workshops were conducted in the summer and were also the focus of Superintendent’s Conference Days held periodically throughout the school year. The workshops functioned to provide teachers with the

technical knowledge to understand, plan, and implement projects and the opportunity to share and collaborate on ongoing projects. Teachers often utilized the COSE list-serve to continue discussions and share ideas about their projects.

“West Side” and “East Side” Schools

This study focused on the factors that influenced six teachers from two schools, “West Side” Middle and High School and “East Side” High School, to embrace or reject project-based learning in science. The “West Side” Middle and High School has an enrollment of approximately 400 students and a faculty of four science teachers who teach life science (7th grade), earth science (8th grade), Regents biology/chemistry (9th and 10th grades) and Regents physics (11th grade). The “West Side” Middle and High School is a theme-based school affiliated with various museums in New York City including the American Museum of Natural History, the New York City Children’s Museum, and the Metropolitan Museum of Art. The mission of the school is to integrate museum learning into the standards-based curriculum whereby teachers collaborate with museum educators to develop and implement projects known as “museum modules.” Module learning occurred at the school and at specified museums throughout New York City 2–3 days a week. For example, during the course of this study, students engaged in the Body Odyssey and Naturalist’s Notebook modules conducted at the NYC Children’s Museum and the American Museum of Natural History/Central Park, respectively.

The “East Side” High School has an enrollment of approximately 400 students and a faculty of three science teachers who teach Regents biology (9th grade), Regents physics (10th grade), and Regents chemistry (11th grade). The overall curriculum at “East Side” High School is based on the New York City New Standards and the Regents Core Curriculum Guidelines as mandated by New York State for all high schools. The school program offers 4 years of study in the major subject areas (english, math, science, social studies) along with 3 years of a foreign language. The goal is to maintain a balance between providing students with a deep understanding of the knowledge needed to master the subject areas and experience with projects to stimulate and develop critical and analytical thinking and curiosity. During the course of this study, 9th grade biology students engaged in independent research projects and

10th grade physics students engaged in the Tennis ball Launcher Project.

Student Profile

The students in both schools are heterogeneous in background and ability; however, because Community School District “A” is a “choice” district, students apply to the high school of their choice and are accepted on the basis of predetermined criteria established by each school. At the “East Side” High School, middle school reading, math scores, and the students’ middle school attendance record are the primary criteria used to determine acceptance. In addition, students must select this school as their first choice in order to be considered for acceptance. At the “West Side” School, the same criteria are utilized for acceptance; however, students with a wide range of abilities are accepted at this school. For both schools, the students come primarily from Manhattan, all socioeconomic backgrounds, and a variety of ethnicities including African American, Asian, Latino, and European American cultures.

RESEARCH METHODS

The Role of the Professional Developer

As professional developer conducting research on the factors that influence the implementation of project-based learning in science, I assumed the dual role of actively participating in program development and staff development as well as that of observer/researcher of the developing science curriculum and pedagogical practices. My work with each of the teachers was dependent upon their professional needs and teaching goals. In September, I met with each of the teachers to discuss and document their professional goals for the upcoming year. Not unexpectedly, most new teachers focused on classroom management, lesson and unit planning, and New York State Regents examination preparation. More experienced teachers focused on refining cooperative grouping strategies, integrating literacy strategies, and developing science projects. The development of professional teaching goals was an ongoing process that was revisited throughout the year to assess teachers’ progress and to reflect upon how their goals changed over time.

The purpose of the weekly professional development visits with each teacher was dependent on their

availability and need. The visits often consisted of a traditional classroom observation followed by a consultation and analysis of the lesson. At other times, the visits would consist of modeling a lesson, working one-on-one with students in the classroom or laboratory, and assisting teachers in lesson, unit, assessment, and project planning and implementation.

I worked to establish a professional yet at times, personal and confidential relationship with these teachers. Opening your classroom door to a "stranger" can be an intimidating experience for some teachers, particularly new teachers who are concerned about their tenure status. My goal was to put them at ease and to assure them that my role was that of support and teacher development and not one of formal evaluation that leads to tenure.

The Project-Planner

Promoting project-based science as way of teaching and learning was a recent initiative supported by the community of science professional developers in this school district. Peter Kindfield, the lead science professional developer in the district, created a "project planner" (See Table I) to be utilized as a template for developing science projects. The goal of this planning approach was to "map backwards" by envisioning what students should know and do by the completion of the project; to write a project description that includes the content, skills, standards, activi-

ties and formal assessments that comprise the project; and to design a time line and detailed plan for project initiation, planning, implementation, reflection, completion, and exhibition.

The project-planner was presented to teachers at the quarterly workshops as a model of project and unit planning. The expectation was for teachers and students to utilize the planner as they mapped out specific goals for a project; reflected upon their prior knowledge, needs, and resources; took appropriate steps to meet their goals and carry out the project; and presented their final projects to an audience of their peers and possibly family and community members.

Data Collection

As a participant observer I assumed the dual role of actively participating in program development and staff development as well as that of observer/researcher of the developing science curriculum and pedagogical practices.

Triangulation of multiple data sources with theory was important for establishing validity of the data (Glesne and Peshkin, 1992). In this study, observations of meetings and classrooms, and collection of artifacts such as curricula, project planners, demographic profiles, student work, and test results served as the primary data sources that were triangulated and related to current theory on project-based learning in science.

Data were collected for a period of one academic year. The researcher was present at each of the schools for one-half day a week for the entire school year in her dual role as researcher/professional developer. The daily research activities varied according to the school's schedule and calendar and usually consisted of a morning meeting with the director and/or co-director, scheduled observations of classes, participation in grade level and departmental meetings, and unscheduled and informal observations of student-student, student-teacher, teacher-teacher, and teacher-administrator interactions.

Domain Analysis

The purpose of analysis is to decode cultural symbols and to reveal the underlying meaning of those symbols (Spradley, 1979). One analytical technique to determine the relationships between cultural symbols is *coding*. In this study about the factors that influence

Table I. Project-Planner—Cycles of Reflection, Planning, and Action (Peter Kindfield, 2000)

Initiation	Teacher presents specific goal (e.g., build a bicycle from parts).
Reflection	Students, with the support of their teacher, reflect on where they are in terms of achieving their goal (i.e., what do we know, what do we need to know, what have we done, and what do we need to do?).
Planning	Students, with the support of their teacher, plan how to proceed towards achieving their goal (i.e., how should we find out what we need to know and how should we go about doing what we need to do? what's the reason for that position? what are the costs and benefits of doing it that way?).
Action	Students, with the support of their teacher, take steps towards achieving their goal. The teacher supports student access to resources and introduces facts and skills, including methods of problem solving and inquiry, as needed by the students.
Exhibition	Students, with the support of their teacher, present their final product to an authentic audience.

the implementation of project-based approaches to teaching and learning science, repeated reading and analysis of observation notes and other study artifacts resulted in a coding scheme. Themes were identified and *external codes* were assigned that related to the original research questions and objectives. Alternately, *internal codes* were assigned to identify new ideas or themes that emerged during the course of the study or introduced by the participants during the classroom observations or informal discussions. A subsequent step in this analysis process was to build connections among codes. These links or bridges were constructed by the use of memos which are utilized to refine and expand on the codes and domains of the analyses. These codes and memos form the basis from which the analysis was conducted and results are reported (Strauss, 1987).

RESEARCH RESULTS

In this study, the level of teacher interest and commitment to project-based learning in science varied considerably. Four teachers embraced aspects of project-based learning in science and two rejected most aspects of teaching project-based learning in science.

"Barbara," the 7th grade life science teacher at the "West Side" Middle School, co-taught with a museum educator and was bound by the mission of the middle school to teach "module" or project-based learning. "Max," the 10th grade physics teacher at the "East Side" School, entered the teaching profession committed to an inquiry-based philosophy of teaching and learning. For Max, doing projects with students naturally fit his developing philosophy and practice of physics teaching. "Dana" was a traditionalist in philosophy and practice, an approach that was exemplified by pedagogy that was primarily focused on Regents examination preparation. However, a shift occurred and a project-based approach was gradually embraced when Dana was afforded the opportunity to co-teach with a botanist from the American Museum of Natural History. Like Dana, "Jessica" was a traditionalist in her teaching of Regents biology, where her practice was primarily focused on "covering" the Regents curriculum. Jessica's transformation to a more project-based teacher can be attributed to her exposure to and discussions about projects during weekly science staff meetings held at the "East Side" High School.

For "Nadine" and "Kathy" the results are fundamentally different from that of Barbara, Max, Dana,

and Jessica. For both did not adopt a project-based approach to teaching science, which can be attributed to Nadine and Kathy entering the teaching profession directly from the workforce (Nadine, MD, and Kathy, an electrical engineer) with no formal educational background and few prior teaching experiences.

What follows are brief vignettes describing the teachers' educational background, philosophy, and practice. For each, factors such as formal preparation in education, number of years teaching, participation in the four project-based learning workshops, and the opportunity to co-teach with colleagues are discussed.

Embraced Project-Based Learning in Science

The Body Odyssey

My initial work with Barbara during her first 2 years of teaching 7th grade life science focused primarily on unit planning and classroom management strategies. Barbara has an MS in Education, attended the four quarterly workshops on project-based learning, and, over time, she contributed examples of her own projects to these workshops. The nature and philosophy of the "West Side" Middle School required Barbara to work in a grade level team in collaboration with museum educators from affiliated museums to design modules such as the Body Odyssey Project. During the Body Odyssey Project, Barbara's 7th grade students were engaged in "active," "hands-on" learning two to three afternoons a week for a period of 2 months at local museums. During these modules, students observed, studied, and explored the oversized human body system exhibits at the New York City Children's Museum. During the "Body Odyssey," students learned about structure, function, and relationships among body systems in their "home" classrooms and at the Children's Museum; conducted library and Internet research on a body system of their choice; and engaged in an ongoing museum module as they designed human body system comic books to be presented to students in a local elementary school. Quite clearly, the goals, mission, and objectives of the middle school fully supported project-based learning. Barbara was comfortable in collaboratively planning, implementing, and evaluating projects.

The Tennis Ball Launcher Project

Max came to his 1st year of physics teaching at the "East Side" High School with the idea that

students should be actively engaged in science inquiry. Max has an MS in Education, attended the four quarterly project-based workshops during his 1st year of teaching, and subsequently presented his own physics “projects” at the workshops the following year. He was eager to learn new strategies and approaches that would allow his students to engage in long-term projects that supported both the NYS Regents physics curriculum and his inquiry-based mode of teaching. Max embraced the idea of “projects” and designed a month-long tennis ball launcher project that met the requirements for the Regents physics syllabus and served as a culminating assessment for a unit on mechanics.

The goal of the tennis ball launcher project was for students to design a mechanical device that would propel a tennis ball the farthest distance. Max utilized the project planner as an organizational tool to describe the goals of the project; to establish the physics content, skills, and standards that students should know and be able to do as a result of engaging in this project; and to develop a workable timeline for his students to complete project activities and assessments.

The Naturalist’s Notebook

Dana came to teach chemistry and biology at the “West Side” High School with a background as a laboratory chemist and an MS in Education. She had been teaching Regents biology and chemistry for 7 years and attended two of the four quarterly project-based science workshops. Dana’s teaching practice could be best described as “traditional,” a style of teaching that was characterized by lecture notes, close adherence to textbook chapter readings, and assignments that rarely strayed from the Regents Core Curriculum Guidelines.

Initially, Dana exhibited resistance to the idea of projects, citing the limited amount of time that she had to “cover” the Regents syllabus for chemistry and biology and to prepare her students for the comprehensive Regents examinations administered in June. However, this resistance slowly diminished as a consequence of a recent school-wide initiative to partner the high school teachers with museum educators similar to the model already in place in the middle school. Dana had the unique opportunity to plan projects and co-teach with a botanist from the American Museum of Natural History. This partnership was the impetus for Dana to learn the latest research about native

plant species and to supplement the Regents requirements through the development of a project called the Naturalist Notebook.

During the “Naturalist Notebook” project, 9th grade students spent two to three afternoons a week for a period of 2 months at Central Park investigating the indigenous flora found in the park and recording their findings in a “Naturalist Notebook” (similar to the kind of authentic notebook a naturalist would keep). Akin to the collaborative design of the Body Odyssey Project that Barbara engaged in with museum educators at the NYC Children’s Museum, Dana worked closely with a botanist from the Museum of Natural History to develop and implement the Naturalist Notebook project. This project required students to learn how to make focused observations of species and represent these observations in detailed diagrams and drawings; to collect data about the various species of plants that they were studying in Central Park; to learn the genus, species, and other unique characteristics of the organisms they were studying; and to write and “publish” their own Naturalist’s Notebook.

Student-Initiated Research Projects

Jessica came to Regents biology teaching at the “East Side” High School with a PhD in Biochemistry, extensive experience in genetic research, and an MS in Education. She had been teaching science at the middle and high school levels for over 10 years and attended two of the four quarterly project-based science workshops. Like Dana, Jessica exhibited resistance to the idea of project-based science citing time constraints in covering the Regents biology curriculum. She initially believed that the demands of the curriculum and the time required to prepare students for the Regents examination in June left little time in the school year for conducting projects. Jessica openly discussed the value and worth of doing projects; however, she believed that her freshmen students needed to first learn the language and vocabulary of biology before they could engage in authentic projects and inquiry.

It is uncertain the exact impetus for change in Jessica’s thinking about projects; however, at a science staff meeting in January, she announced that her biology students would engage in “original” independent research projects as their culminating projects for the academic year. This shift appears to be attributed to Jessica’s regular attendance at these weekly science

staff meetings that often focused on the development and implementation of science projects and where Max frequently discussed the progress and pitfalls of his tennis ball launcher project.

Feeling more comfortable with the notion of 9th graders doing projects, Jessica's students worked in teams of three to four to develop a research question related to any topic in biology, prepare and submit a research proposal for review, edit their proposal, conduct their research, gather and analyze data, and present their findings at a poster session in the spring.

Rejected Project-Based Learning in Science

Nadine came to her 1st year of teaching Regents chemistry at the "East Side" High School with a background as a medical doctor. She had no formal teacher preparation and subsequently her pedagogy was primarily rooted in her own experiences as a student taking Regents chemistry in New York City many years ago. This prior experience as a student seemed to be her point of reference in most discussions that we engaged in about strategies for teaching science and offered some explanation for why she was so reluctant to engage in most forms of inquiry and projects. Nadine's primary goal was to achieve a high passing rate on the Regents chemistry exam in June. Subsequently, her classes consisted of mostly lecture notes and daily homework review that modeled Regents questions and problems. In addition, Nadine seemed to be apprehensive about conducting chemistry labs and allowing students to use chemicals and flammable materials. This anxiety resulted in "dry labs" where students worked in groups to solve prescribed Regents chemistry problems. Nadine never seemed to move beyond a very traditional and didactic mode of teaching for the test.

Kathy came to her 1st year of physics teaching at the "West Side" High School with experience as an electrical engineer working for a major utility company in New York City. Like Nadine, she had little

to no formal teacher education preparation except for limited substitute teaching experience in the New York City Public Schools. Unlike Nadine, Cathy experienced many problems with classroom management that seemed to persist throughout her 1st year of teaching. Issues of classroom control surfaced time and again as the class dug in their heels and remained uncooperative and disinterested in learning physics for practically the entire year. In response, Kathy resorted to more lecture and less inquiry and became reliant on the overhead projector to deliver notes and to assign problems and homework. At times, Cathy did make some effort towards incorporating labs and demonstrations into her curriculum; however, her teaching style remained primarily didactic in nature. Ultimately, the students had the final word when only 3 out of 30 students sat for the Regents exam in June. None of the three students passed the exam.

DISCUSSION OF RESULTS

Several factors emerged that appeared to play a significant role as to whether teachers adopted project-based approaches to teaching science. These factors include the attainment of an M.S. in Education, the number of years teaching, the number of project-based learning workshops attended, and the opportunity to collaborate and co-teach with other teachers. What follows in Table II is a comparison of these factors.

Nadine and Kathy were both 1st year teachers with no formal preparation in the field of education, little to no participation in the project-based learning workshops, and no opportunities to co-teach with other science teachers. The combination of these factors may have contributed to the fact that they did not adopt project-based learning in their teaching. Moreover, having had few prior teaching experiences, it seems "logical" that they would focus their attention on learning basic teaching skills such as lesson

Table II. Factors Influencing the Adoption of Project-Based Learning in Science

Teachers name	Subject/grade	Project name	MS in education	No. of Years of teaching	No. of workshops attended	Coteacher	Passing Regents (%)
Barbara	Life Sci/7	Body odyssey	Yes	2	4	Yes	No Regents
Max	Physics/10	Tennis ball launcher	Yes	1	4	No	65
Dana	Biology/9	Naturalist notebook	Yes	7	2	Yes	73
Jessica	Biology/9	Independent research	Yes	10	2	No	95
Nadine	Chem/11	Rejected projects	No	1	0	No	75
Kathy	Physics/11	Rejected projects	No	1	1	No	0

planning, classroom and time management, assessment development, and Regents test preparation.

It is interesting to note that Max was also a 1st year teacher, with student teaching being his only prior teaching experience. In addition, Max did not have an opportunity to co-teach with other science teachers; however, he did have a master's degree and not only attended the project-based learning workshops, he also presented the results of his projects to his colleagues at similar workshops the following fall.

For Barbara, clearly it was the school-wide philosophy of module or project-based teaching that seemed to generate such enthusiasm and support for her teaching approach. The fact that teachers not only plan but also teach collaboratively at the "West Side" Middle School further supported the notion of project-based teaching and learning. Availability of resources in terms of time, funding, equipment, professional development, and additional teaching staff allowed for students to engage in meaningful project-based learning at this school. As a teaching professional, Barbara came to the "West Side" Middle School with a master's degree in education and a commitment to further her knowledge and skill through ongoing professional development.

Dana and Jessica initially exhibited a traditional and didactic mode of teaching; nevertheless, over time they began to develop an enthusiasm and willingness to explore inquiry-based and project-based approaches to teaching science. Dana clearly benefited from having a coteacher, a botanist and museum educator from the American Museum of Natural History to plan with and coteach her biology classes. Collaborating with another teacher freed up time for Dana to explore project-based approaches and to design, implement, and evaluate projects. In this regard, it is interesting to note that Dana did not institute any project-based approaches to her Regents chemistry curriculum and teaching, her other teaching responsibility that she taught without the assistance of a coteacher.

For Jessica, her involvement in weekly staff meetings where Max often discussed the progress of his own tennis ball launcher project may have had some influence in her "sudden" decision to conduct projects with her own biology students. It is interesting to note that Jessica was never outwardly opposed to projects and student-initiated research, but was mostly concerned with the time required to plan, implement, and evaluate such projects. Over time, she began to develop time management strategies that allowed her to balance the Regents biology requirements

with student-initiated projects. During the subsequent school year, Jessica designed a more structured research project that involved a variety of controlled studies using Wisconsin Fast Plants®.

In the case of Nadine and Cathy, the results were not unexpected. Both were novice teachers with little to no formal education preparation and who approached the teaching of science in the way they were taught science in secondary school and college. Modifying their practice on a week-to-week basis where the primary goal was to either survive or teach for the test proved fruitless. Whenever the classroom situation turned stressful, both resorted to the use of more control, worksheets, and overhead transparencies.

In terms of the overall passing rate on the Regents examinations, over 75% of Nadine's students passed the Chemistry Regents that year. Cathy's students didn't bode as well. Only 3 out of 60 students actually sat for the Regents physics exam and none of these students passed the exam. Nadine met her primary teaching goal and that, in itself, was quite worthy. Helping her to see the worthiness of inquiry and projects in the science classroom is a goal that was never realized. Nadine chose not to renew her teaching contract with the district the following year. Cathy was not invited to renew her contract.

IMPLICATIONS FOR SCIENCE PROFESSIONAL DEVELOPMENT

This study was designed to examine the factors that influenced the implementation of project-based approaches to science teaching and learning. The implications of such a study are noteworthy.

Preservice and in-service professional development experiences influence the degree to which teachers implement project-based approaches in their science teaching. In this study, those teachers who had a formal education background and who continued their professional development in the form of one-on-one professional development and attendance at workshops were more inclined to embrace project-based approaches to teaching. In addition, experienced teachers who had more than 5 years of teaching experience seem to be more comfortable with "experimenting" with new approaches to teaching than novice teachers. Novice teachers with little to no formal education background seem less able to focus on innovative practices such as project-based learning and were more concerned with the daily routine of lesson planning, classroom management, and

standardized test preparation. For those teachers who did embrace project-based approaches to teaching science, external support in terms of time, staffing, equipment, and funding were necessary in order to make the adoption of such curriculum and teaching practices possible.

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